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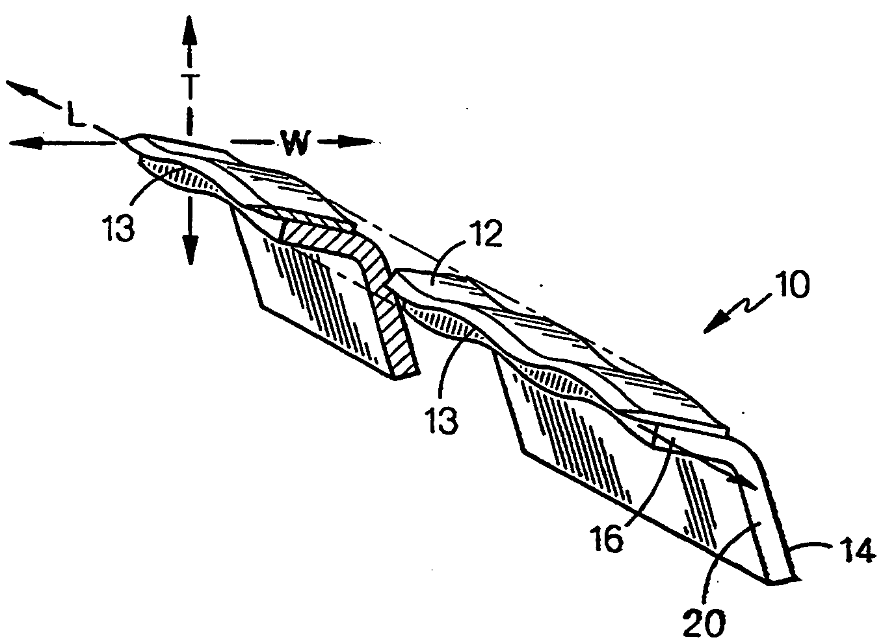

(57) Abstract

A strenghtened blade for a shaving razor including a generally flat blade member having a width along a width axis, a length along a transverse length axis, and smaller dimensions along a thickness axis that is normal to both the width axis and the length axis, the blade member having a nonlinear front cutting edge defined by a plurality of waves having crests and valleys extending above and below the length axis in a direction that is parallel to the thickness axis.

RAZOR BLADE AND CARTRIDGE INCLUDING SAME AND METHOD OF MAKING SAME

Background of the Invention

The invention relates to a razor blade, a cartridge including the razor blade, and a method of making the razor blade.

Razor blade cartridges typically include plastic housings that are attached to or made integral with a handle and have one or more fixed or movable razor blades mounted on the housing. The housing typically includes a guard structure in front of the blades that engages and stretches the skin in front of the blades and a cap structure behind the blades that slides over the skin. On razors, the blade tangent angle for a blade is defined as the angle made by a line drawn through the central longitudinal axis of the blade cross section and extending from the cutting edge of the blade, and a tangent line drawn between the top surfaces of the structures contacted by the skin immediately in front of the cutting edge and the tip of the cutting edge. Blade exposure is defined as the distance of the cutting edge above or below a tangent line drawn between the top surfaces of the structures in front of and behind the cutting edge; the distance is measured normal to the tangent line.

Razor blades are typically sharpened and processed to provide the desired shape and hardness prior to mounting on the housing. In one type of razor design, flat razor blade members having straight cutting edges are supported on L-shaped supports that are resiliently mounted on the housing.

In designing razor blade cartridges, it is desirable to provide a close shave while avoiding nicks and cuts by adjusting such parameters as blade sharpness, blade tangent angle, and exposure. Slicing cuts typically occur when a straight cutting edge is inadvertently moved sideways (i.e., transverse to the usual upward or downward motion of the razor) on the skin such that the straight razor edge slices into the skin. This sideways movement can cause the blade edge to act as a knife cutting cleanly through the skin.

It is also desirable to provide general shaving comfort and overall performance. It is also desirable to have a blade edge that has sufficient strength to survive the rigors of shaving and to provide confidence to the razor blade designer that the blade edge will not distort or deflect owing to the shaving forces applied to the

blade edge.

Summary of the Invention

In one aspect, the invention features, in general, a blade for a shaving razor that has a nonlinear front cutting edge that is defined by a plurality of waves having crests and valleys extending above and below a transverse length axis. The nonlinear cutting edge is provided on a blade member that is generally flat and has a width along a width axis, a length along a transverse length axis, and smaller dimensions along a thickness axis defined normal to both the length and width axes. The non-linear front cutting edge generally extends along the length axis, and the waves extend above and below the length axis in a direction that is parallel to the thickness axis.

Certain implementations of the invention may include one or more of the following features. In certain implementations, the blade includes an "L-shaped" support under the blade member; the support is thicker than the blade member, and includes an upper portion to which the blade member is attached and an extension extending downward therefrom; the upper portion has a plurality of waves that are aligned with the waves of the blade member. The blade member has a length of between 1 and 2 inches, and has between 2 and 24 waves (most preferably between 6 and 18 waves). The waves have an amplitude between crests and valleys of less than 0.012", preferably between 0.002" and 0.004", and most preferably about 0.003". The blade member is made of metal between about 0.002" and about 0.010" thick, preferably between about 0.003" and about 0.004" thick. The waves have an amplitude of distance between the crests and valleys that is between 50% and 150% of the thickness of the metal, most preferably between 75% and 125% of the thickness. The waves preferably extend throughout the width of the blade member.

In another aspect, the invention features, in general, a blade with a wavy blade member as has already been generally described, the waves having an amplitude of distance between crests and valleys selected to be greater than an amplitude that causes unnecessary cuts in the skin if the cutting edge is slid sideways on the skin and to be less than an amplitude that causes a decrease in shaving comfort when compared to a linear front cutting edge. Preferably the waves have an amplitude between crests and valleys of greater than 0.001" and less than 0.012", most preferably between 0.002"

and 0.004".

In another aspect, the invention features, in general, a blade with a strengthened wavy blade member as has already been generally described, the strengthened blade member having a moment of inertia that is at least 20% greater (preferably at least 35% greater) than a moment of inertia for a flat, linear edged, blade member made of material having the same thickness as the strengthened blade member with waves.

In another aspect, the invention features, in general, a razor blade cartridge including a housing and a blade with a nonlinear, wavy front cutting edge as has already been generally described.

Certain implementations of the invention may include one or more of the following features. In certain implementations, the cartridge has a plurality of blades, and the waves in one blade member preferably are aligned with the waves in another blade member. The housing has connecting structure for connection to a handle and pivoting structure providing pivoting of the housing with respect to the handle. The connecting structure and the pivoting structure are provided by a structure that provides a pivotal connection between the cartridge and the handle. In some implementations the blade members are mounted on an upper portion of an "L-shaped" support that also has a downward extension that is slidably mounted within a slot in the housing, the upper portion having waves aligned with the waves in the blade member. In some other implementations blade(s) may be fixedly mounted on a platform portion of the housing, and may be separated by a spacer.

In another aspect, the invention features, in general, a method of making a blade that includes sharpening a generally flat blade member to form a linear cutting edge that extends along a length axis, and thereafter deforming the blade member to cause a nonlinear, wavy front cutting edge as has already been generally described.

Certain implementations of the invention may include one or more of the following features. In certain implementations, the blade member is mounted on a portion of a support prior to the deforming step, and both the blade member and the portion of the support underneath the blade member are deformed. The blade member is preferably mounted on the support by spot welds located at valleys or crests (preferably valleys) of the waves. The deforming includes bending between opposed

dies that preferably have nonmatching surfaces so as to provide regions for material flow of the blade member and the support portion thereunder during deforming. The dies have surfaces that cause three-point or four-point bending of the blade member and the support portion thereunder.

Embodiments of the invention may include one or more of the following advantages.

The provision of waves in the cutting edge of the blade can avoid "slash" cuts that occur when a blade is accidentally side-slipped along the cutting edge (length) axis. Since the non-linear blade edge has an undulating edge, the edge, when it side slips, merely "scrapes" across the skin without slicing into the skin.

In addition, hairs being cut can be subjected, in successive strokes, to different portions of the blade having different blade tangent angles, potentially providing for a closer cutting of hairs with varying orientation. The wavy nature of the blade may provide for better skin engagement and skin-stretching, and, in the case of a two or three blade system, the first blade functions as a front guard for a blade behind it.

The wavy nature of the blade and/or its support additionally strengthens the blade structure and promotes blade stiffness, reducing uncontrolled blade edge flexure which may cause unpredictable or variable blade contact angles and/or exposure with the surface of the skin.

Other advantages and features of the invention will be apparent from the following description of the preferred embodiments thereof and from the claims.

Brief Description of the Drawings

Fig. 1 is a perspective view of a razor blade.

Fig. 2 is a plan view of the Fig. 1 blade.

Fig. 3 is a partial elevation of the Fig. 1 blade.

Fig. 4 is a vertical, sectional view of the Fig. 1 blade prior to bending.

Fig. 5 is a vertical, sectional view of a razor blade cartridge including two blades as shown in Fig. 1.

Fig. 6 is a vertical, sectional view of an alternative razor blade cartridge including an alternative razor blade.

Fig. 7 is a diagram showing a press and fixturing system used to provide

waves in the Fig. 1 blade.

Fig. 8 is a partial elevation showing the die portions for providing three-point bending in the Fig. 7 system.

Fig. 9 is a partial elevation showing the die portions for providing four-point bending in the Fig. 7 system.

Fig. 10 is a graph (not drawn to scale) showing the height of a blade member versus length for a single wave of a hypothetical blade member having waves that follow a sine curve.

Fig. 11 is a front view showing the alignment of valleys and crests of waves of cutting edges in front and back blades of the Fig. 5 cartridge.

Fig. 12 is an front elevation of the blade member of the Fig. 1 blade.

Description of the Preferred Embodiments

Referring to Figs. 1-3, there is shown razor blade 10 including blade member 12 and angled support 14. Blade member 12 is generally flat and has a width along width axis W, a length along transverse length axis L, and smaller dimensions along thickness axis T that is normal to width axis W and length axis L. Support 14 has upper portion 16 to which blade member 12 is preferably attached by thirteen spot welds 18. Support 14 also has elongated extension 20 thereunder.

Blade member 12 has a nonlinear front cutting edge 13 that generally extends along length axis L and preferably is defined by twelve waves 15 having crests and valleys extending above and below length axis L in a direction that is parallel to thickness axis T. Waves 15 extend rearward from front cutting edge 13 parallel to each other preferably over the entire width of blade member 12. Upper portion 16 has twelve waves 17 corresponding to and aligned with waves 15. The valleys of the waves occur at spot welds 18. Waves 15, 17 are smooth and have crest to valley amplitudes below 0.012", preferably between 0.002" and 0.004", and most preferably about 0.003". The amplitude of 0.003" is believed to be sufficiently high to provide good protection against "slash" sideways cuts but not so high as to cause undue discomfort or irritation and propensity to cause nicks and cuts during normal up and down shaving strokes. The amplitude also yields acceptable overall shaving comfort values as compared to flat blades based upon shave tests and accepted statistical

analysis. It is believed that a value of crest to valley amplitude greater than 0.001" provides a minimum level of protection against sideways slash cuts and that values above 0.012" will result in undue irritation. As shown in Fig. 3, there is a slight gap 19 between blade member 12 and upper portion 16 owing to spot welds 18 therebetween.

Fig. 4 shows undeformed blade 10' including flat blade member 12' and support 14' prior to forming. Blade member 12' is preferably made of 0.003" or 0.004" thick razor blade quality stainless steel which is martensitic and has a uniform thickness section with a width "d" of about 0.033" and a sharpened portion extending in front for a dimension "c" of about 0.012". Upper portion 16' preferably has a dimension "b" of 0.0325". Support 14' is made of 0.011" thick stainless steel. Extension 20' of support 14' extends downward from upper platform 16 a distance of 0.0596".

Referring to Fig. 5, razor blade cartridge 22 has housing 24 with arcuate surface 26 for providing a pivotal shell type bearing connection to a razor handle (not shown). Housing 24 supports two movable blades 10 in respective slots 25 in the side walls of the housing. Blades 10 are biased upward to the positions shown in Fig. 5 by spring members 28. The crests 80 and valleys 82 of cutting edge 13 of the first blade 10 are preferably aligned with the crests 80 and valleys 82 of the cutting edge of the second blade 10 in order to avoid regions of excessive exposure that could cause undue nicking (see Fig. 11). Cartridge 22 also has flexible fin guard member 30 in front of the blades and lubricating strip 32 at cap section 34. U.S. Patent No. 4,498,357, which is hereby incorporated by reference, describes such a moving-blade cartridge design.

Referring to Fig. 6, alternative razor blade cartridge 40 includes two fixed blades 42 on sandwiched platform support 44. Cartridge 40 also has guard member 46 and cap member 48. Blades 42 have waves of the same shape and amplitude as blade member 12, and the crests and valleys of the two blades are aligned. U.S. Patent No. 4,026,016, which is hereby incorporated by reference, describes such a fixed blade, cartridge design.

In manufacture, blade member 12' is preferably sharpened, coated, and sintered according to techniques well-known in the industry to obtain undeformed blade 10' as shown in Fig. 4. E.g., U.S. Patents Nos. 3,652,443; 3,761,374; and 3,829,969,

which are hereby incorporated by reference, describe such techniques. The blade member 12' is preferably secured to support upper portion 16' by laser spot welding, as described in U.S. Patent No. 4,379,219, incorporated by reference herein.

Referring to Figs. 7-9, an undeformed blade 10' is formed in apparatus 49 between upper die 52 and lower die 50 to provide waves 15 and 17 (Fig. 3). Portion 16' of support 14' (Fig. 4) is supported on lower die 50. Upper die 52 is moved downward toward and contacts blade member 12'. With continued downward movement of upper die 52 toward lower die 50, blade member 12' and upper portion 16' are deformed, resulting in waves 15 and 17 extending throughout the width of blade member 12' and the underlying area of upper portion 16', respectively. Upper die 52 continues downward until it reaches stop 54, which determines the amount of maximum deflection of blade member 12' and upper portion 16'. Upper die 52 is then raised, and blade 10' elastically returns to approximately 50% of the maximum deflected value. Thus, a maximum die deflection of amplitude of about ±0.003", which corresponds to a crest to valley amplitude of about 0.006", results in a preferable final crest to valley wave amplitude of about 0.003".

Opposed dies 50 and 52 have nonmatching surfaces so as to provide regions for material flow during forming of undeformed blade member 12' and undeformed upper support portion 16' into formed blade member 12 and formed upper support portion 16. In particular, referring to Figs. 8 and 9, upper die 52 is used with lower die 50 (Fig. 8) for three-point bending, and upper die 52 is used with lower die 50' (Fig. 9) for four-point bending. Three-point or four-point bending is used to permit material flow during the deflection and deformation process and to permit forming of upper portion 16' while extension 20' remains flat. In both cases, upper die 52 has thirteen semi-circular ridges 56 with center-to-center spacing of 0.119", a depth "e" of 0.0453", a radius 72 of 0.0315", and a small flatter central portion 58 of radius 73 of 0.069" having an arc segment length of about 0.001". Lower die 50 (Fig. 8) has twelve circular ridges 60 with center-to-center spacing of 0.119", a depth "£" of 0.0358", a radius 74 of 0.0596", and a flat space "g" between ridges of 0.0096". Lower die 50' (Fig. 9) has 24 ridges 62 having center-to-center spacing of 0.595", a depth 75 of 0.0178", a radius 76 of 0.0298", a small flatter area 64 with a radius 77 of 0.0535" having an arc segment length of about 0.001", a flat spacing between ridges "h" of

0.0048", and a base dimension "i" of 0.0547". Ridges 56, 60, and 62 extend parallel to each other over a distance at least as long as the width of blade member 12'. In the three-point bending of Fig. 8, the three contact points for bending the waves in the blade edge for each wave are provided by an upper ridge 56 and the two lower ridges 60 on both sides. In the four-point bending of Fig. 8, the four points of contact for forming each wave are provided by two upper ridges 56 and the two lower ridges 62 between them. In both types of bending, spot welds 18 are located in the valleys under semicircular ridges 56 in order to provide better control of the amplitude of deflection and to provide for a stiffer structure.

Referring to Fig. 12, in the current preferred system, the distance 78 between successive wave crests is set at 0.119", and the preferred crest to valley wave amplitude is about 0.003". With three point bending (Fig. 8), the resulting non-linear wave edge has a wave crest radius R1 of slightly more than the 0.0596" radius 74 of ridge 60 and a wave valley radius R2 of slightly more than the 0.0315" radius 72 of ridge 56, owing to the release of the deflected blade member after the maximum die deflection. Because the radius of ridge 60 is about twice the radius of ridge 56, the resulting crests and valleys have a ratio R1/R2 of about 2:1. With the four point bending of Fig. 9, the formation of a single wave crest around two ridges 62 results in approximately the same crest radius R1; approximately the same valley radius R2 is caused by ridges 56. Thus, four-point bending with the apparatus of Fig. 9 also results in a ratio R1/R2 of about 2:1. The crests and valleys could also have a ratio R1/R2 of about 1:1 (this can be described by a sine wave) or of about 1:2. Preferably the ratio R1/R2 is between 0.5 and 2. Four-point bending is preferred over three-point bending.

Blades 10 (Fig. 5) and blades 42 (Fig. 6) are formed using similar dies.

When the resulting blades are mounted on a housing, they have varying blade tangent angles along their lengths. During shaving, with successive strokes over the same skin area, different portions along the length of blade 10 or 42 will engage the same hair. By subjecting the hair to blade portions having different blade tangent angles, closer shaving can result.

The use of waves in the blade can avoid "slash" cuts that occur when a blade is accidentally side-slipped along the cutting edge axis; slash cuts can be problems with women shavers in particular. The wavy nature of a blade can also

provide for better skin flow management, and the first blade can act as a better guard for the second blade behind it in two or three blade systems. This is because the effective contact length with a wavy cutting edge on the skin is substantially longer than with a flat blade, thus providing more points of contact in stretching the skin.

The waves also make the blade member a stiffer structure which is subject to less bending during shaving, tending to better maintain designed exposures and blade tangent angles during shaving than flat blade counterparts (i.e., made of the same thickness material). The increased strength provided to blade member 12 by the wavy structure can be estimated by assuming that the wave follows a sine curve and calculating and comparing moments of inertia (which determine the blade stiffness and resistance to deflection) for the wavy blades and the weaker undeformed flat blades. Referring to Fig. 10, the following formula can be used to describe the location of a midline through the blade member 12, Y_n, as a function of length, x, and the upper surface $Y_n + h/2$, and the lower surface, $Y_n - h/2$:

$$Y_n = £ \sin \frac{2\pi\ x}{l}\ ;\ Yn + (h/2);\ Yn - (h/2)$$

where: £ = 1/2 the crest to valley wave amplitude,
l = wavelength, and
h = blade thickness.

The moment of inertia, I_{xx}, for the wavy blade can be calculated as follows:

$$I_{xx} = \int_A y^2\, dA = \int_x \int_{(y_n - h/2)}^{(y_n + h/2)} y^2\, dydx = \frac{h^3 l}{12} + \frac{h£^2 l}{2}$$

The moment of inertia for a flat sheet (without waves) can be calculated as follows:

$$\textit{Flat Blade } (£=O):\ I_{xx} = \frac{h^3 l}{12}$$

The change in moment of inertia, and thus the additional blade stiffness, caused by forming the waves in an initially flat blade is given by the following formula:

ΔBlade Stiffness (per unit length):

$$\Delta I_{xx} = I_{xx}(wavy) - I_{xx}(flat) = \frac{h£^2}{2}$$

The ratio of the moment of inertia for a wavy blade to the moment of inertia for a flat

blade is given by the following formula:

$$\Delta \textit{Blade Stiffness Ratio: } R = \frac{I_{xx}(wavy)}{I_{xx}(flat)} = 1 + 6\left(\frac{£}{h}\right)^2$$

These formulas were used to calculate the moments of inertia for a wavy blade member (having a crest to valley amplitude of 0.003") and a flat blade member (used as a control) for two thicknesses, 0.003" and 0.004". The results of the moment of inertia calculations, the ratio of the moment of inertia for a wavy blade member to that for the flat blade member, and the % increase of moment of inertia of the wavy blade member over that of the flat blade member are presented below in Table 1.

TABLE 1

Calculations of Blade Stiffness (Moment of Inertia per Unit Length): Wavy vs. Control Blades					
Flat Edges					
h Thickness		I			
0.004		5.333×10^{-9}			
0.003		2.25×10^{-9}			
Wavy Blade					
h thickness	£ 1/2 wave amplitude	I	Ratio (I(wavy)/ I (flat))	ΔI	%Increase I wavy over I flat
0.004	0.0015	9.833×10^{-9}	1.844	4.5×10^{-9}	84.4%
0.003	0.0015	5.625×10^{-9}	2.500	3.375×10^{-9}	150.%

From the above table it is seen that the moment of inertia for a wavy blade of 0.004" thickness increases 84.4% over that of a flat blade of the same thickness, and for a wavy blade of 0.003" thickness the moment of inertia increase is 150%. It thus appears that the added stiffness provided by the wave shape can be particularly significant for blade members made of the thinner 0.003" thick metal.

In multiple blade systems (such as shown in Fig. 5 or Fig. 6), it is preferable to align the crests 80 and valleys 82 of the first blade with the crests 83 and valleys 84 of the second blade, respectively, as shown in Fig. 11.

Other embodiments of the invention are within the scope of the appended claims. E.g., the waves could be provided at only the front portion of blade member 12, and, instead of extending parallel to each other perpendicular to the front cutting edge, the waves could alternately converge and diverge as they extend rearward from the front edge. Also, in multiple blade systems, the crests and valleys can be unaligned with one another.

CLAIMS

1. A blade for a shaving razor including a generally flat blade member having a width along a width axis, a length along a transverse length axis, and smaller dimensions along a thickness axis that is normal to both of said width axis and said length axis, said blade member having a nonlinear front cutting edge that generally extends along said length axis and is defined by a plurality of waves having crests and valleys extending above and below said length axis in a direction that is parallel to said thickness axis.

2. The blade of claim 1, further comprising a support under said blade member, said support including an upper portion to which said blade member is attached and an extension extending downward therefrom, said upper portion having a plurality of waves aligned with said plurality of waves of said blade member.

3. The blade of claim 2, wherein said support is thicker than said blade member.

4. The blade of claim 1, wherein said blade member has a length of between 1 and 2 inches, and has between 2 and 24 of said waves.

5. The blade of claim 4, wherein said blade member has between 6 and 18 of said waves.

6. The blade of claim 1, wherein said waves have an amplitude of distance between said crests and valleys of less than 0.012".

7. The blade of claim 6, wherein said waves have an amplitude of distance between said crests and valleys of between 0.002" and 0.004".

8. The blade of claim 1, wherein said blade member is made of metal having a thickness, and said waves have an amplitude of distance between said crests and valleys that is between 50% and 150% of said thickness.

9. The blade of claim 8, wherein said waves have an amplitude of distance between said crests and valleys that is between 75% and 125% of said thickness.

10. The blade of claim 1, wherein said waves extend throughout the width of said blade member.

11. The blade of claim 1, wherein said blade member is made of metal between about 0.002" and about 0.010" thick.

12. The blade of claim 10, wherein said blade member is made of metal

between about 0.003" and 0.004" thick.

13. The blade of claim 2, wherein said blade member is spot welded to said support, and wherein said wave valleys are aligned with said spot welds.

14. A razor blade cartridge comprising

a housing, and

a blade mounted on said housing, said blade including a generally flat blade member having a width along a width axis, a length along a transverse length axis, and smaller dimensions along a thickness axis that is normal to both said width axis and said length axis, said blade member having a nonlinear front cutting edge that generally extends along said length axis and is defined by a plurality of waves having crests and valleys extending above and below said length axis in a direction that is parallel to said thickness axis.

15. The cartridge of claim 14, further comprising a support under said blade member, said support including an upper portion to which said blade member is attached and an extension extending downward therefrom, said upper portion having a plurality of waves aligned with said plurality of waves of said blade member, said housing having a slot receiving said extension, said extension being slidably mounted within said slot.

16. The cartridge of claim 15, wherein said support is thicker than said blade member.

17. The cartridge of claim 14, wherein said blade member has a length of between 1 and 2 inches, and has between 2 and 24 of said waves.

18. The cartridge of claim 17, wherein said blade member has between 6 and 18 of said waves.

19. The cartridge of claim 14, wherein said waves have an amplitude of distance between said crests and valleys of less than 0.012".

20. The cartridge of claim 19, wherein said waves have an amplitude of distance between said crests and valleys of between 0.002" and 0.004".

21. The cartridge of claim 14, wherein said blade member is made of metal having a thickness, and said waves have an amplitude of distance between said crests and valleys that is between 50% and 150% of said thickness.

22. The cartridge of claim 21, wherein said waves have an amplitude of

distance between said crests and valleys that is between 75% and 125% of said thickness.

23. The cartridge of claim 14, wherein said waves extend throughout the width of said blade member.

24. The cartridge of claim 14, wherein said blade member is made of metal between about 0.002" and about 0.010" thick.

25. The cartridge of claim 24, wherein said blade member is made of metal between about 0.003" and about 0.004" thick.

26. The cartridge of claim 15, wherein said blade member is spot welded to said support, and wherein said waves are aligned with said spot welds.

27. The cartridge of claim 14, wherein said cartridge has a plurality of said blades including blade members, and said waves in one blade member are aligned with waves in another blade member.

28. The cartridge of claim 14, wherein said cartridge has a plurality of said blades, and said blades are fixedly mounted in said housing.

29. The cartridge of claim 14, wherein said cartridge has a plurality of said blades, and said blades are movably mounted in said housing.

30. The cartridge of claim 28, wherein said blades are separated by a spacer and mounted on a platform portion of said housing.

31. The cartridge of claim 14, wherein said housing has connecting structure for connection to a handle and pivoting structure providing pivoting of said blades with respect to said handle.

32. The cartridge of claim 30, wherein said connecting structure and said pivoting structure are provided by structure that provides a pivotal connection between said cartridge and said handle.

33. A method of making a blade comprising

sharpening a generally flat blade member having a width along a width axis, a length along a transverse length axis, and smaller dimensions along a thickness axis that is normal to said width axis and said length axis, said blade member having a linear cutting edge that extends along said length axis, and

thereafter deforming said blade member to cause said cutting edge to be nonlinear and have a plurality of waves having crests and valleys extending above and

below said length axis in a direction that is parallel to said thickness axis.

34. The method of claim 33, further comprising mounting said blade member on a portion of a support prior to said deforming step, and wherein said deforming includes deforming both said blade member and said portion of said support underneath said blade member.

35. The method of claim 34, wherein said support is thicker than said blade member.

36. The method of claim 34, wherein said mounting includes spot welding said blade member to said support at spot welds, and wherein said spot welds are located at said valleys or said crests.

37. The method of claim 34, wherein said mounting includes spot welding said blade member to said support at spot welds, and wherein said spot welds are located at said valleys.

38. The method of claim 33, wherein said deforming includes bending between opposed dies.

39. The method of claim 38, wherein said opposed dies have nonmatching surfaces so as to provide regions for material flow of said blade member during deforming.

40. The method of claim 39, wherein said dies have surfaces that cause three-point bending of said blade member.

41. The method of claim 39, wherein said dies have surfaces that cause four-point bending of said blade member.

42. The method of claim 34, wherein said deforming includes bending between opposed dies having nonmatching surfaces so as to provide regions for material flow of said blade member and said support during deforming.

43. The method of claim 33, wherein said blade member has a length of between 1 and 2 inches, has between 2 and 24 of said waves, and is made of metal between about 0.002" and about 0.010" thick, and wherein said waves have an amplitude of distance between said crests and valleys of less than 0.012".

44. The method of claim 43, wherein said blade member has between 6 and 18 of said waves, and is made of metal between about 0.003" and about 0.004" thick, and wherein said waves have an amplitude of distance between said crests and valleys

of between 0.002" and 0.004".

45. A blade for a shaving razor including a generally flat blade member having a width along a width axis, a length along a transverse length axis, and smaller dimensions along a thickness axis that is normal to both of said width axis and said length axis, said blade member having a nonlinear front cutting edge that generally extends along said length axis and is defined by a plurality of waves having crests and valleys extending above and below said length axis in a direction that is parallel to said thickness axis,

said waves having an amplitude of distance between said crests and valleys selected to be greater than an amplitude that causes unnecessary cuts in the skin if the cutting edge is slid sideways on the skin and to be less than a amplitude that causes a decrease in shaving comfort when compared to a linear front cutting edge.

46. The blade of claim 45, wherein said waves have an amplitude of distance between said crests and valleys of greater than 0.001" and less than 0.012".

47. The blade of claim 46, wherein said waves have an amplitude of distance between said crests and valleys of between 0.002" and 0.004".

48. The blade of claim 45, wherein said blade member is made of metal having a thickness, and said waves have an amplitude of distance between said crests and valleys that is between 50% and 150% of said thickness.

49. The blade of claim 48, wherein said waves have an amplitude of distance between said crests and valleys that is between 75% and 125% of said thickness.

50. A strengthened blade for a shaving razor including a generally flat blade member having a width along a width axis, a length along a transverse length axis, and smaller dimensions along a thickness axis that is normal to both of said width axis and said length axis, said blade member having a nonlinear front cutting edge that generally extends along said length axis and is defined by a plurality of waves having crests and valleys extending above and below said length axis in a direction that is parallel to said thickness axis,

said blade member having a moment of inertia that is at least 20% greater than a moment of inertia for a flat blade member made of material of the same thickness as said strengthened blade and having a linear blade edge.

51. The blade of claim 50, wherein said moment of inertia that is at least

35% greater than a moment of inertia for a flat blade member made of material of the same thickness as said strengthened blade and having linear blade edge.

52. The blade of claim 51, wherein said moment of inertia for said blade member with waves is calculated using the formula

$$I_{xx} = \int_A y^2\, dA = \int_x \int_{(y_n - h/2)}^{(y_n + h/2)} y^2\, dydx = \frac{h^3 l}{12} + \frac{h£^2 l}{2}$$

and moment of inertia for said flat blade member with waves is calculated using the formula

$$\textit{Flat Blade } (£=O)\text{:}\quad I_{xx} = \frac{h^3 l}{12}$$

where: £ = 1/2 the crest to valley wave amplitude,

l= wavelength, and

h = blade thickness.

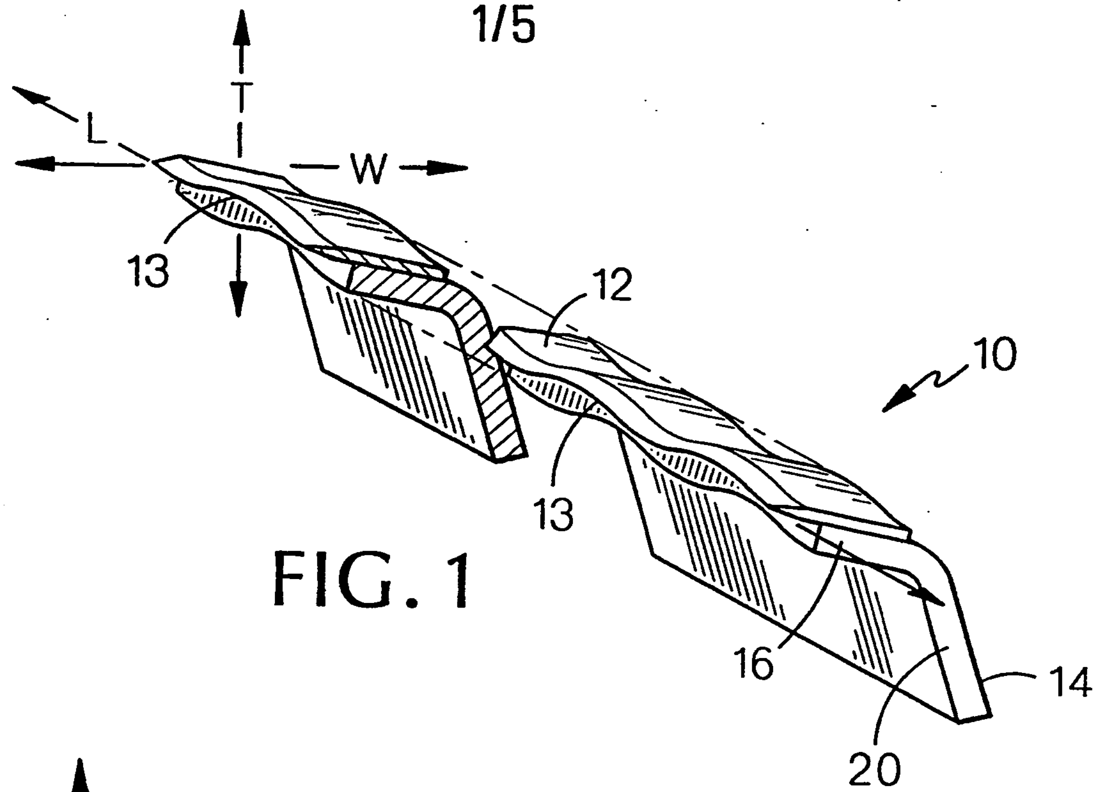

FIG. 1

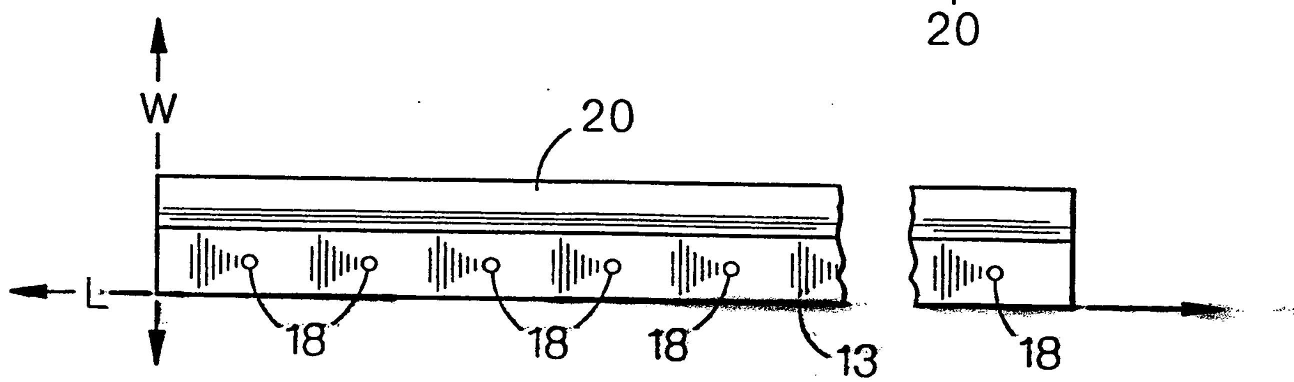

FIG. 2

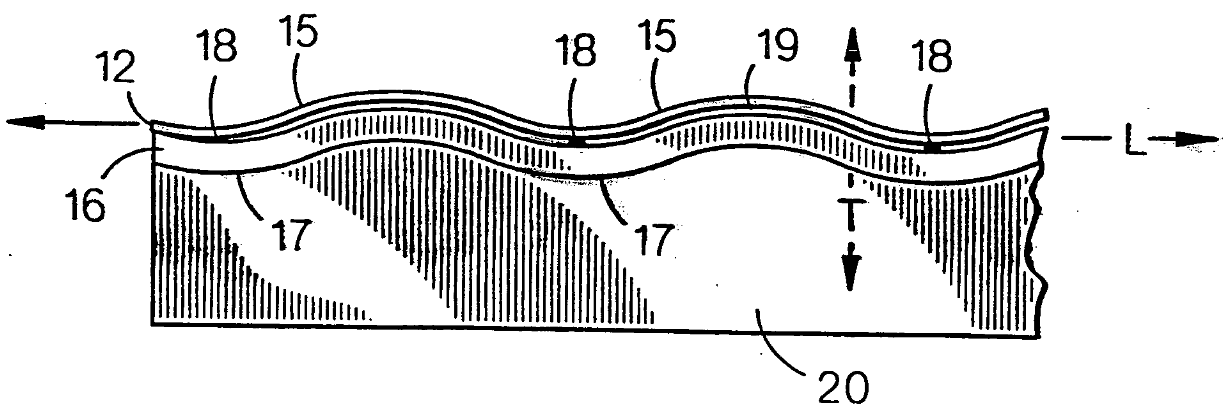

FIG. 3

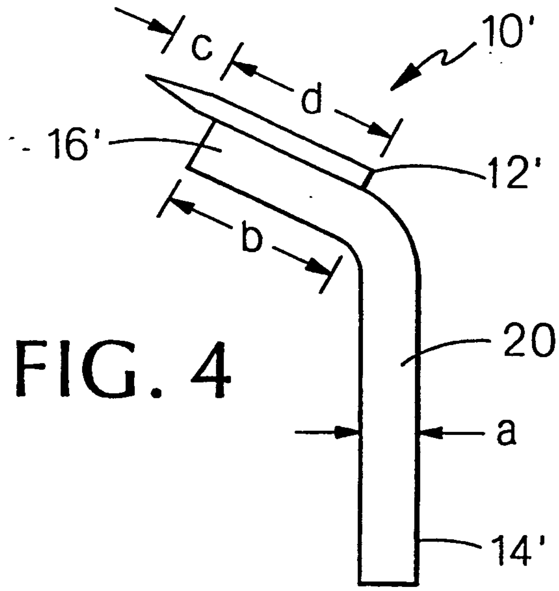

FIG. 4

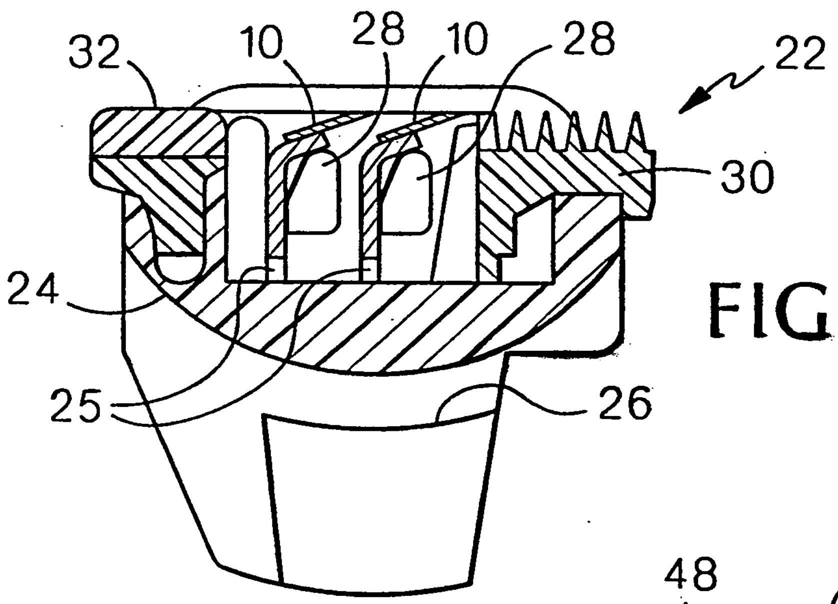

FIG. 5

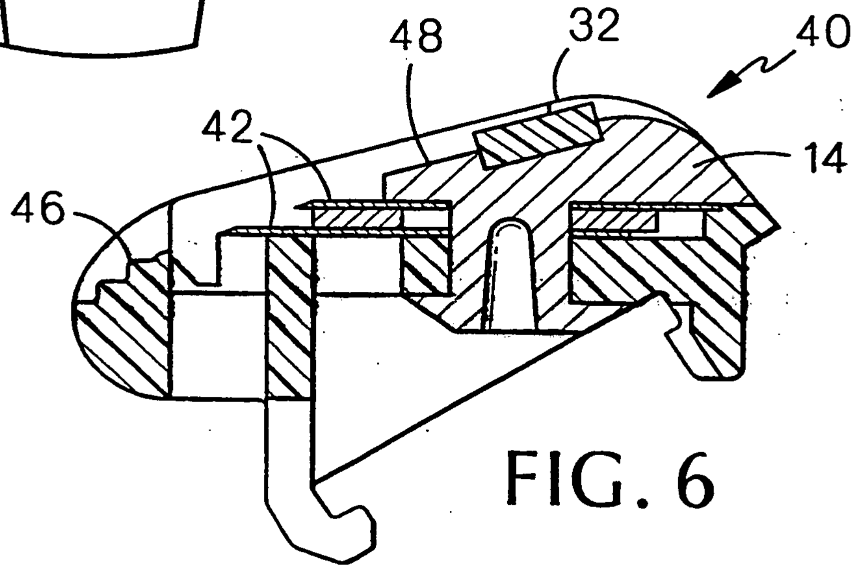

FIG. 6

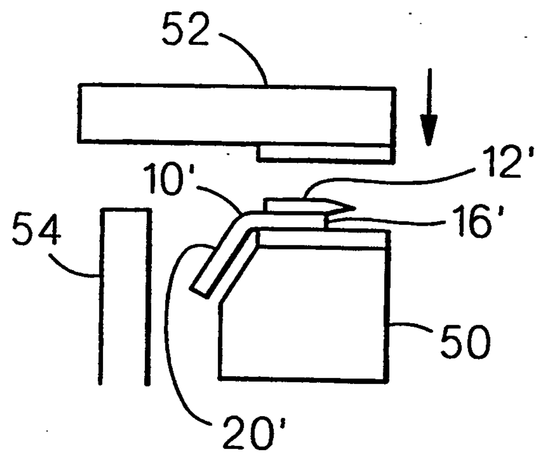

FIG. 7

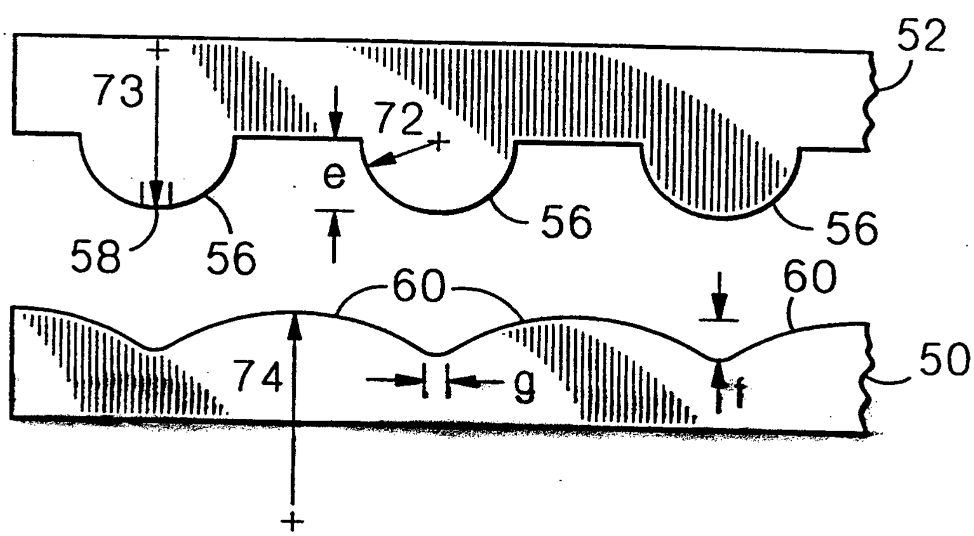

FIG. 8

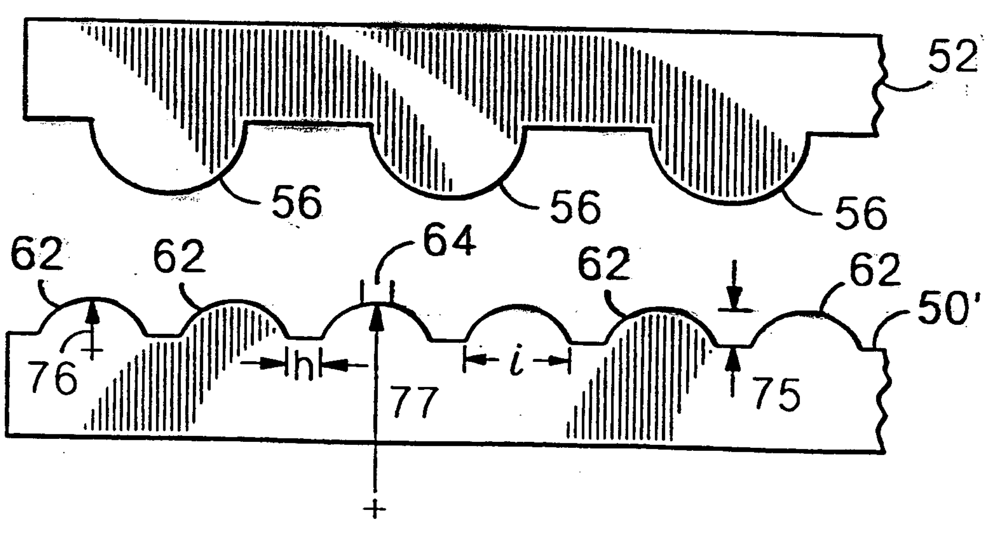

FIG. 9

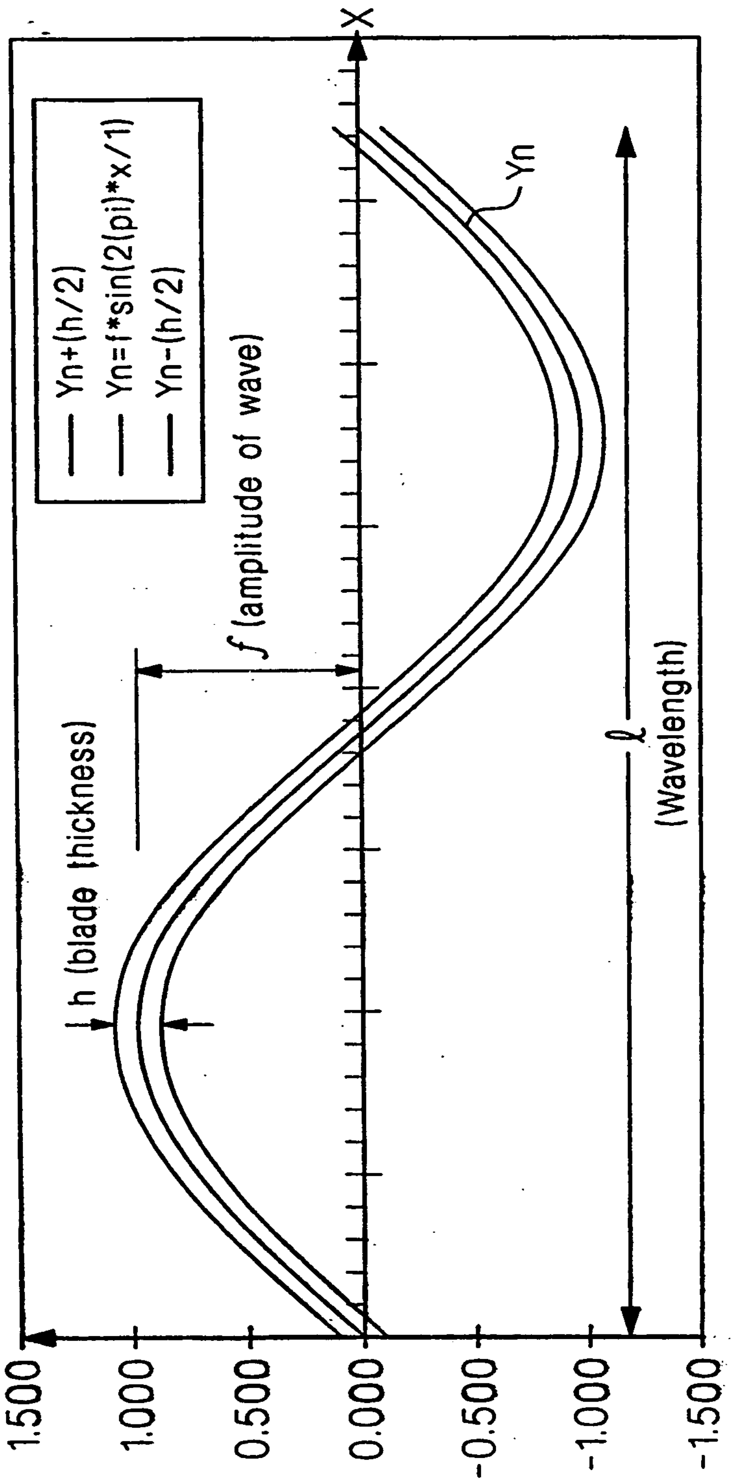
X
Yn+(h/2)
Yn=f*sin(2(pi)*x/1)
Yn-(h/2)
f (amplitude of wave)
h (blade thickness)
Yn
ℓ
(Wavelength)
1.500
1.000
0.500
0.000
-0.500
-1.000
-1.500

FIG. 10

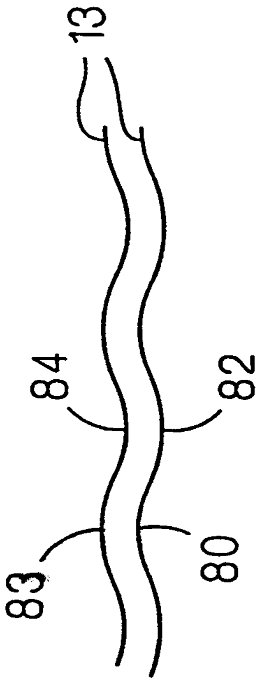

FIG. 11

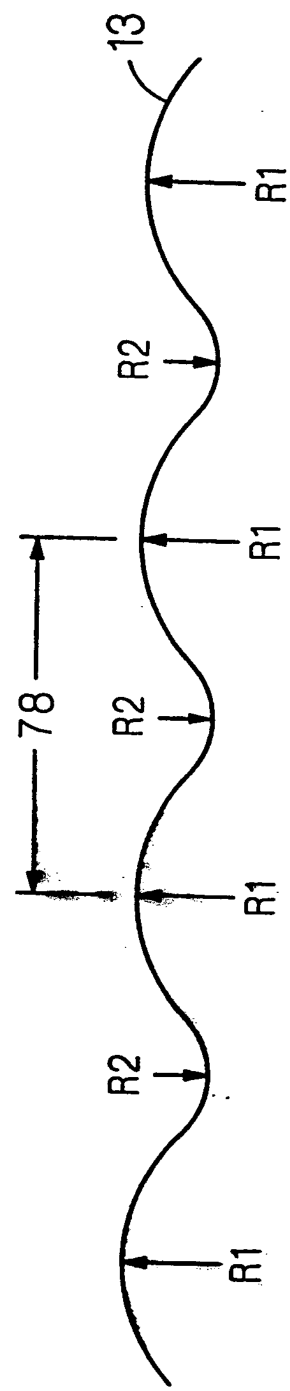

FIG.12

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B26B 21/56, B24B 3/48, B26B 21/54, B21D 53/64

A3

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US 08/807,144 (CON)
Filed on 27 February 1997 (27.02.97)

(71) Applicant (*for all designated States except US*): THE GILLETTE COMPANY [US/US]; Prudential Tower Building, Boston, MA 02199 (US).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): HAHN, Steve, Syng-Hi [US/US]; 7 Trinity Court, Wellesley Hills, MA 02181 (US).

(74) Agents: GALLOWAY, Peter, D.; Ladas & Parry, 26 West 61st Street, New York, NY 10023 (US) et al.

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

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With international search report.

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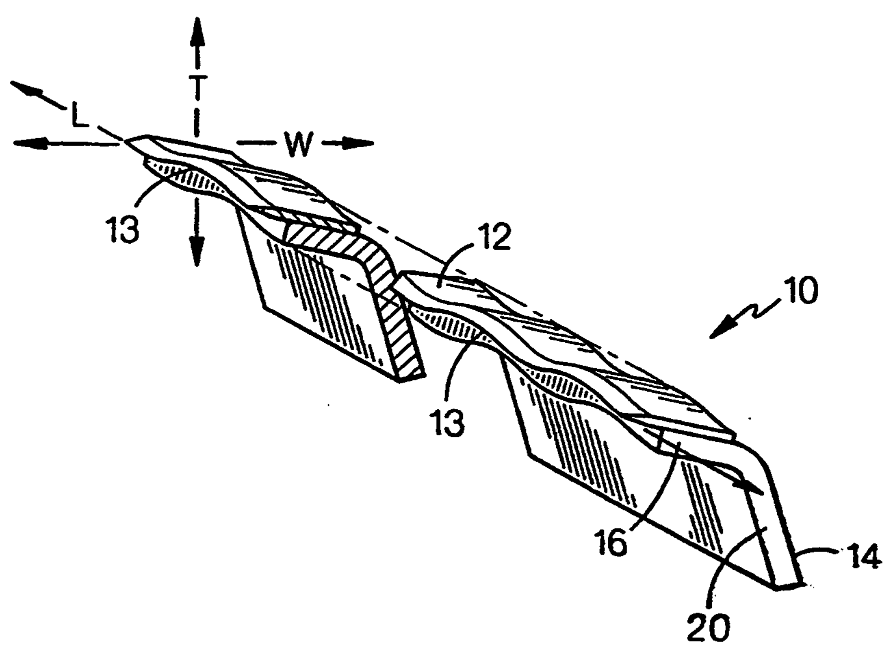
(54) Title: RAZOR BLADE AND CARTRIDGE INCLUDING SAME AND METHOD OF MAKING SAME



(57) Abstract

A strenghtened blade for a shaving razor including a generally flat blade member having a width along a width axis (W), a length along a transverse length axis (L), and smaller dimensions along a thickness axis (T) that is normal to both the width axis and the length axis, the blade member having a nonlinear front cutting edge (13) defined by a plurality of waves (15) having crests and valleys extending above and below the length axis in a direction that is parallel to the thickness axis.

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INTERNATIONAL SEARCH REPORT

Interna al Application No
PCT/US 98/03761

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B26B21/56 B24B3/48 B26B21/54 B21D53/64

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B26B B24B B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 85 02809 A (THE GILLETTE COMPANY) 4 July 1985 see page 3, line 3 - page 5, line 39; figures 1-6	1,14,45
A		33,50

X	GB 676 089 A (MULLER) 23 July 1952 see the whole document	1,45
A		33,50

X	DE 739 561 C (MÜLLER) 19 April 1944 see the whole document	1,45

A	US 4 608 782 A (CHYLINSKI HENRYK J) 2 September 1986 see the whole document	33

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
14 August 1998	04.09.98

Name and mailing address of the ISA	Authorized officer
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PCT/US 98/03761

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 445 385 A (EVER-READY RAZOR PRODUCTS) 8 April 1936 see the whole document -----	50

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 98/03761

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

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because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
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3. ☐ Claims Nos.:
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Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

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see additional sheet

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This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-32, 45-49

2. Claims: 33-44

3. Claims: 50-52

INTERNATIONAL SEARCH REPORT

Information on patent family members

Interna al Application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 8502809 A	04-07-1985	BR 8407242 A EP 0167571 A GB 2151532 A JP 61500773 T	26-11-1985 15-01-1986 24-07-1985 24-04-1986
GB 676089 A		NONE	
DE 739561 C		NONE	
US 4608782 A	02-09-1986	CA 1252277 A	11-04-1989
GB 445385 A		NONE	